

than in *P. ucalcyon*; a streak in the cell along the median nervure, below which, between the second and third median nervules, is a long angular-shaped cream-coloured spot, which extends almost to the outer margin; a cream-coloured spot about the middle of the inner margin, and a long broad spot joining it above the submedian nervure: secondaries golden brown, crossed above the middle by a wide cream-coloured band, which is much dentated on the outer edge; the inner margin of the wing thickly clothed with orange-yellow hairs. Underside: primaries very similar to the upperside, but paler in colour; secondaries paler than above, the veins all black, the basal portion of the wing deep reddish brown, not crossed by a light-coloured band, as in *P. ucalcyon*; a large black spot on the costal margin and a white dot at the base. Head, antennæ, and thorax black; abdomen brown, with a row of yellow spots on each side; legs black.

Expanse 4 inches.

Hab. Upper Congo (*Mus. Druce*).

This species is allied to *P. ucalcyon*, Hewitson, and *P. auriger*, Butler, but very distinct from either. *P. harpagon*, Grose Smith (*Ann. & Mag. Nat. Hist. ser. 6, vol. v. p. 224*), is the same as Mr. Butler's species, and therefore will not stand.

XLII.—*On the Development of the Shoulder-girdle of a Plesiosaur* (*Cryptoclidus oxoniensis*, *Phillips, sp.*) *from the Oxford Clay.* By C. W. ANDREWS, F.G.S., Assistant in the British Museum (Natural History).

THE structure of the pectoral girdle in the Plesiosauria has been the subject of much controversy, and various conflicting views as to the homologies of some of its parts are held. It is not, however, necessary here to recapitulate these different opinions, but for the present purpose it will be sufficient to mention that the chief points in dispute are:—(1) The nature of the anterior ventral bar of the scapula; (2) the homology of the anterior structure, which has been variously regarded as omosternalia or as the clavicular arch.

The abundant Plesiosaurian remains obtained by Mr. Leeds from the Oxford Clay near Peterborough render it possible to describe several stages in the growth of an Elasmosaurian type of pectoral arch, which seem to throw some light on the points at issue. The species, to which the remains here described belong, is the commonest of those found in the locality above

mentioned, and may be provisionally referred to the genus *Cryptoclidus* *, a division established by Professor Seeley † for the reception of forms which are distinguished from *Muraenosaurus* by possessing vertebræ with broader, shorter, and more concave centra, less cylindroid zygapophyses, and, in the cervical region, shorter neural spines; coracoids with large postero-lateral prolongations; clavicles which meet in the middle line, the interclavicle being absent; radius of great vertical depth and ulna transversely elongated. It is not clear whether Professor Seeley himself considers *Cryptoclidus* a distinct genus or merely a subgenus of *Muraenosaurus*, since he speaks of it in both ways; but there can be no doubt that it is entitled to generic rank, since in the number and form of the cervical vertebræ the animals referred to it are totally different from the *Muraenosaurus*; moreover, in the rest of the skeleton, *e. g.* the pectoral arch, constant differences can be detected.

The following diagnosis of the genus may be given, the characters being determined from the type of *C. platymerus* and other specimens in the Leeds collection:—Skull about one third of the length of the neck, with broad blunt snout. Mandible with very short symphysis. Cervical vertebræ 31–32 in number; centra short and with rather deeply concave oval articular surfaces, the width of which is considerably (as 7 to 5) greater than the length of the centrum; zygapophyses cylindroid, zygosphenal articulation well developed. There are 2 or 3 pectoral vertebræ and 21 or 22 dorsal, all with concave articular ends. There appear to be 3 or 4 sacral vertebræ, distinguished by bearing ribs, which are expanded at the outer ends and articulate partly on the centrum and partly on the neural arch. The abdominal ribs are very strongly developed and are arranged in about ten transverse rows, each consisting of a median piece and two lateral pairs. The chevrons, at least in the adult, impress the vertebræ both in front and behind them. In the adult the ventral rami of the scapulæ meet in median symphysis and extend back to meet the median anterior prolongation of the coracoids, closing the coraco-scapular foramina; anteriorly they extend beneath the clavicles. These latter are triangular membrane-bones which meet in median symphysis; there is no known interclavicle. The coracoids are very thick and massive in front,

* It is not improbable that this genus is identical with *Colymbosaurus*, established by Professor Seeley in 1874 on the evidence of a shoulder-girdle from Ely. If this should prove to be the case, the name *Colymbosaurus*, having the priority, must be adopted for these Plesiosaurs.

† Proc. Roy. Soc. vol. li. (1892) p. 145.

but thin posteriorly; their hinder outer angles are prolonged into short thick rod-like projections. The humerus when fully grown is immensely expanded at its distal end. The radius is very large and vertically elongate; the ulna very wide transversely. On the postaxial side of this latter there is usually a small ossification, which may fuse with it or with the ulnare, and in one specimen is in contact with the humerus; this bone may perhaps be regarded as a pisiform. In the pelvis the pubis and ischium met in the middle line in the adult, closing the obturator foramen. The ilium does not touch the pubis, a character, however, which seems to be universal among the Plesiosaurs. The femur is not nearly so much expanded distally as the humerus.

In a future paper I hope to give a complete account of some of the more important osteological characters of this genus.

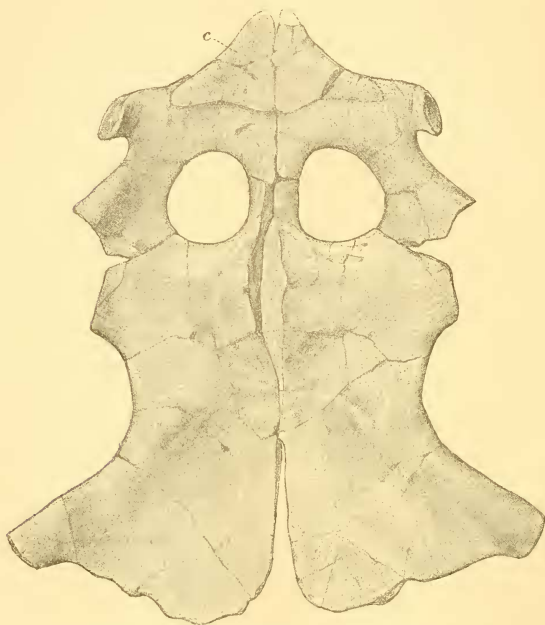
With regard to the specific name of this reptile there is some difficulty. Examination of a considerable number of more or less complete sets of associated bones shows that there are two forms possessing the generic characters given above and differing only in size when compared at corresponding ages as determined by the condition of the scapulæ, cervical ribs, &c. Mr. Leeds is of opinion that this may indicate the occurrence of sexual dimorphism in these Plesiosaurs, the larger bones, which are always proportionately more massive and possess more strongly marked surfaces for muscle-attachment, being those of males, while the smaller, more lightly built skeletons are those of females. Such sexual dimorphism does occur in reptiles; for example, it is well-marked in the case of *Sphenodon*, a circumstance of some interest, since that reptile shows some affinities with the Sauropterygia. At present, therefore, it seems best to refer all these remains to a single species, the name of which will be *Cryptoclidus oxoniensis*, this specific name having been applied by Phillips* to cervical vertebræ which differ only in size from those of *Cryptoclidus platymerus*, Seeley. Moreover, Phillips rightly referred to the same species scapulæ (described as ischia), dorsal vertebræ, and other bones which resemble those of the type specimen *C. platymerus*, but belonged to a younger individual.

Turning now to the description of the shoulder-girdle (fig. 1), and taking the adult condition first, we find that the scapula is of the usual triradiate form, consisting of a backwardly directed

* 'Geology of Oxford,' 1871, p. 307.

bar carrying the articular surfaces for the coracoid and humerus, an upwardly directed process, the blade, and a broad ventral ramus, which extends forward and inwards to the middle line, where it unites with its fellow of the opposite side.

Fig. 1.

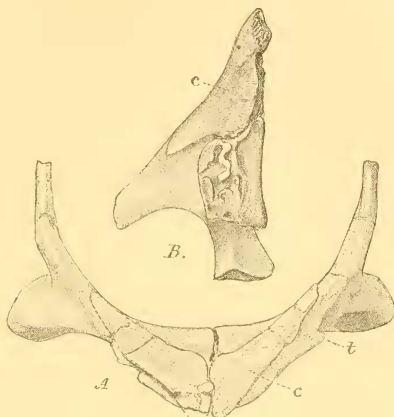


Shoulder-girdle of *Cryptoclidus oroniensis* (adult), from above.
About $\frac{1}{5}$ nat. size. c, clavicle.

The posterior bar is triangular in section. Its inner edge forming the outer border of the coraco-scapular foramen is sharp, thickening slightly as it approaches the coracoidal surface; the upper outer border is rounded and passes into the posterior edge of the blade; the lower outer border rises into a rough ridge about 2 centim. from the glenoid surface, and then runs forwards and inwards, forming on the outer

surface of the scapula the boundary between the ventral and lateral regions of the bone ; anteriorly it terminates at the edge in a strong outwardly directed tubercle (*t*, fig. 2 *A*) bearing a smooth facet at its summit.

Fig. 2.



A.—Scapulae and clavicle of *Cryptoclidus oxoniensis* (adult), from front. About $\frac{1}{6}$ nat. size. *c*, clavicle.

B.—Symphyseal surface of left scapula with clavicle (*c*) in position. About $\frac{1}{8}$ nat. size.

The surfaces for the humerus and coracoid meet at right angles in an irregular slightly concave line about 6.5 centim. long. The glenoid surface forms half a rather irregular oval measuring 6.5 centim. from the middle of the base to the vertex of the curve, while the coracoidal surface is an isosceles triangle, the sides of which are slightly convex and measure 8.2 centim. in length ; the base is formed by the line of junction with the glenoid surface. This latter is fairly smooth, while the surface for the coracoid is extremely rugose.

The dorsal ramus of the scapula is compressed from within outwards and is from 4 to 5 centim. wide at the upper end, which is occupied by a rough depressed surface, to which a small suprascapular cartilage seems to have been attached. The anterior border, which is slightly convex, is rough, as if growth in that direction had not yet ceased.

The anterior ventral ramus is the largest and most important part of the scapula; its anterior border, a continuation of that of the dorsal ramus, is at first rounded and concave as far as the prominent tubercle above mentioned, then comparatively sharp and thin, running inwards and forwards till, by a sharp curve, it passes into the median border, with which it makes an angle of about 45° . The hinder border, forming the anterior as well as part of the inner edge of the coraco-scapular foramen, increases in thickness from without inwards and then backwards to the junction with the anterior prolongation with the coracoid, the surface for union with which is nearly semicircular and is at right angles to the scapular symphysis. This latter (fig. 2 *B*), which occupies the inner end of the thick posterior portion of the ventral ramus, forms a nearly rectangular surface, measuring 7 or 8 centim. long by 5 centim. deep; its anterior dorsal angle is rounded, while its anterior ventral angle is prolonged forward as the inner edge of the thin anterior portion of the ventral ramus. The symphyseal surface is deeply pitted and channelled by blood-vessels which passed into the thorax by a foramen between the two scapulæ at about the middle of the symphysis.

The outer surface of the ventral ramus of the scapula is nearly flat, but the visceral surface is divided into two areas—a high posterior portion, where the bone is very thick and convex antero-posteriorly, and a thin, depressed, slightly concave anterior area, which is triangular in form and is separated from the posterior portion by a step which runs directly outwards from the upper anterior angle of the symphysis. This anterior region of the scapula does not meet the corresponding portion of the opposite side in the oldest specimen I have been able to examine, but is separated from it by a narrow V-shaped interval. Probably the two sides were united by cartilage, and in very old individuals ossification may have extended inwards till they met in the middle line.

The above description is founded on a left scapula (R. 1966), which, with an associated complete clavicle, is preserved in the Leeds collection at the British Museum. Recently, on examining Mr. Leeds's private collection, I noticed a shoulder-girdle wanting the left scapula and clavicle, but found associated with numerous vertebræ and the greater part of the pelvis. Comparison of the two scapulæ shows that they are exactly similar both in size and in details of structure, even to the vascular impressions on the symphyseal surface, so that there can be no doubt that they belong to one and the same individual. The vertebræ and other bones present the

characters of the genus given above, and appear to have been portions of the skeleton of a large (? male) adult animal.

When the scapulæ are placed together in their natural position (fig. 2 *A*), a line drawn on their visceral surface from the tip of one dorsal ramus to the other forms an arc rather greater than a semicircle.

The left clavicle (the right is imperfect) is in the form of a scalene triangle (*c* in figs. 1 and 2). Its anterior and posterior borders are slightly concave and meet in the thickened and rounded outer angle. On the ventral surface of this latter are irregular rugosities, which fit into the depressions in a corresponding roughened area on the upper surface of the scapula near its outer margin, so that the two bones appear to have united at this point in an imperfect loosely connected suture: in some other specimens I have been able to examine this connexion seems to have been more perfect. This union of the clavicle with the scapula is a point of considerable interest, since in the Nothosauridæ and Lariosauridæ the outer end of the clavicle is usually suturally united with the ventral plate of the scapula. The inner border of the clavicle is somewhat thickened and has a bevelled edge by which the bone united with its fellow of the opposite side. This symphysial surface presents a ridged and fibrous appearance, quite unlike that found in the cartilage bones of these animals. In all the clavicles examined this inner border, at about one third of its length from the front angle, is divided into two portions by an oblique notch, which runs outward and backwards into the bone for some distance.

The clavicles of *C. platymerus* figured by Seeley are simply the parts of those bones which lie in front of this division, the remainder being lost. The significance of this notch is not clear; it may either have allowed the passage of a blood-vessel or may possibly mark the position of an interclavicle which has either escaped notice owing to its small size or never ossified. The greatest thickness of the clavicle is near the inner border, where it measures 1·5 centim. through; the whole surface is marked by lines of growth which radiate from the middle of the bone. Its dimensions are:—

	centim.
Length of anterior edge	17
" posterior "	14
" inner "	12

When the clavicle is in its natural position on the visceral surface of the scapula its hinder border rests against the front of the thick posterior portion of the ventral ramus of that bone, its anterior and inner portions extending rather

beyond the underlying thin portion of the scapula, so as to be visible on the ventral surface. Probably, however, in a later stage the scapula grew forward and inward, completely shutting in the clavicles and extending the symphysis of the scapulæ to their extreme anterior end. This appears to have taken place in the shoulder-girdle of *Colymbosaurus* figured by Seeley * and in that of *Elasmosaurus* figured by Cope †, in both of which genera, however, the clavicles are unknown.

The general form of the coracoids at this stage is shown in fig. 1. These bones are extremely thick and massive in the inter-glenoidal region, but further back become very thin except at the lateral borders, which are thick and rounded and are produced postero-laterally into short stout prolongations with truncated ends.

Successively younger stages may now be compared with the mature or nearly mature condition above described.

The first of these is represented by a left scapula, which, allowing for more imperfect ossification, closely resembles the last, and no doubt belonged to an individual of the same species. In this specimen the anterior ramus was already well developed and had grown back in the middle line for some distance towards the median prolongation of the coracoid, but had not yet quite reached it, as can be seen from the fact that it terminates posteriorly in a sharp edge. The symphyseal surface is marked with pits and vascular impressions, but probably was still separated from the scapula of the opposite side. The thin anterior portion of the scapula is much smaller than in the last stage, and does not extend so far forwards and inwards, so that the scapulæ were separated in front by a much more widely open V-shaped interval, and a much larger part of the clavicles would be visible from the ventral surface. The dorsal ramus is shorter and its anterior border was incompletely ossified. The clavicle is unfortunately wanting, but the impression of its posterior edge shows that it occupied exactly the same position in relation to the scapula as in the last specimen.

The next stage is represented by a shoulder-girdle (no. 05) in Mr. Leeds's collection (fig. 3 A) ‡; the left scapula only is wanting, but the bones are somewhat crushed. This crushing does not, however, affect the anterior ramus of the scapula,

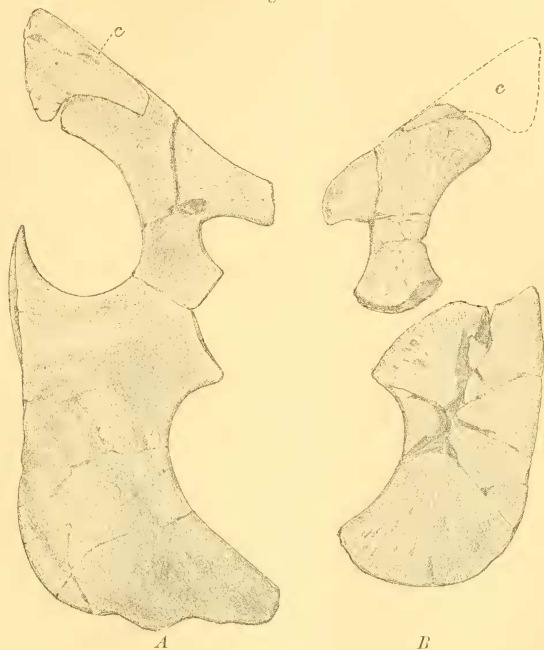
* Quart. Journ. Geol. Soc. vol. xxx. (1874) p. 447.

† Trans. Amer. Phil. Soc. vol. xiv. (1870) p. 51, fig. 7.

‡ The clavicle should be placed a little further inwards than is shown in this figure.

the inner end of which must have been separated by a considerable interval from its fellow of the opposite side, and had not yet commenced to grow back towards the coracoids, so that the coraco-scapular foramina were widely open to one another in the middle line. Of the thin anterior portion

Fig. 3.



A.—Right half of an immature shoulder-girdle of *Cryptoclidus oxoniensis*, from above. About $\frac{1}{5}$ nat. size.

B.—Left half of a younger specimen of the same, from above. About $\frac{1}{5}$ nat. size. c, clavicle.

supporting the clavicles only a very small part near the outer border is yet developed, so that the whole of the clavicle except a small portion of the outer limb would be visible from below. As in the adult, the clavicles met in the middle line.

The coracoids, which must have been separated by a thick pad of cartilage, had commenced to grow forward in the middle line towards the scapulæ, and their anterior prolongation already extended considerably in advance of the surfaces for the scapulæ.

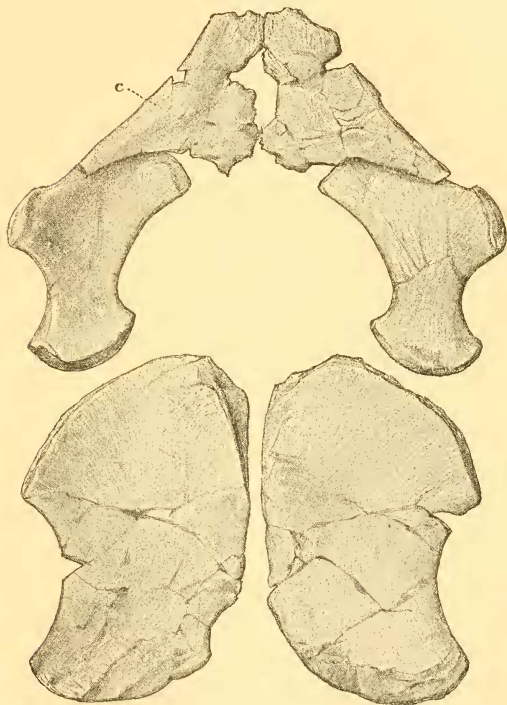
The next specimen (Leeds Coll. 37, R. 2416) is a shoulder-girdle wanting the clavicles and part of the right scapula, but found in association with the greater portion of the vertebral column, the paddles, and some of the pelvic bones, all of which, allowing for their immature condition, show the generic characters given above. At this age (fig. 3 *B*) the anterior ramus of the scapulæ is very incompletely developed, so that the two bones were widely separated in the middle line. On the upper surface of the thickened anterior edge is a slight depression, which comparison with older stages shows to be that occupied by the extreme outer angle of the clavicle, which in this stage therefore is entirely anterior to the scapula. The coracoids, which were of the form shown in fig. 3 *B*, had as yet not commenced to grow forward in the middle line, and their outer posterior angles were not prolonged into projecting processes.

The last pectoral girdle (Leeds Coll. 36, R. 2417) (fig. 4) is that of a young individual of the smaller (? female) type. The scapulæ show that it is in about the same stage of development as that last described, though considerably smaller. This specimen is here described and figured on account of its completeness and because it forms part of the nearly entire skeleton now mounted in the Gallery of Fossil Reptiles at the Natural History Museum*. The cervical vertebræ, abdominal ribs, &c. all agree essentially in structure with the type specimen of *Cryptoclidus platymerus*. The clavicles are of the same form as the adult specimen described above, but smaller and very much thinner. The structure of their inner border shows that they already met in median symphysis, at least in front. The extreme end of the external angle is broken away, but the ventral surface at the fracture shows the beginning of the rough surface of contact with the anterior border of the scapula. This latter is in much the same condition as in the stage last described, but is perhaps a little older. The coracoids also are very similar to those last described.

* The clavicles of this specimen have been figured by Professor Seeley under the name *Plesiosaurus durobrivensis* in the 'Proceedings of the Royal Society,' vol. li. (1892) p. 133, fig. 5, where also other parts of the skeleton are described and measurements given.

Although the elements of this pectoral arch are free from matrix, and in no way united with one another, there can be little doubt that the figure represents very nearly their relative position during life. In the first place, the fact that the clavicles met in the middle line is shown by the structure of

Fig. 4.



Complete shoulder-girdle of a young specimen of *Cryptoclidus oxoniensis* (Leeds Coll. 36). About $\frac{1}{3}$ nat. size.

their median border; in the next, the position of the outer ends of the clavicles with regard to the scapulæ is settled by the depression on the anterior border of those bones into which the outer part of the hinder edge of the clavicle fits,

and, as was mentioned above, a rough surface marks the exact position on the scapulæ of the outer angle of the clavicles. The relative position of the scapulæ to one another is thus fixed, and that of the coracoids is easily determined.

It may here be remarked that in comparing scapulæ of these animals at different ages, one circumstance is of great assistance, namely that the inner edge of the bone forming the outer border of the coraco-scapular foramen undergoes scarcely any growth during life except at the ends, this thin sharp edge in the adult scapula being the thin edge of the young stages almost unchanged. If, therefore, in comparing an older and a younger scapula the latter be superimposed upon the former, so that the corresponding portions of their inner borders are coincident, the area added to the older bone since it was in the condition of the younger one is clearly seen.

Turning now to the consideration of the conclusions that may be drawn from an examination of the series of shoulder-girdles above described, we find that in the condition shown in fig. 4 the pectoral arch, as far as its ossified portions are concerned, is similar in all essential respects to that found among the Nothosauridæ and Lariosauridæ, the scapulæ consisting of a hinder portion bearing the surfaces for articulation with the coracoids and humerus, a dorsally directed blade, and an anterior ventral portion, against the anterior edge of which the hinder end of the clavicle was fixed, the two bones apparently uniting in a rude suture, as has been already pointed out; in many members of the families above mentioned the sutural union of scapula and clavicle is very perfect. The clavicles, as in the Nothosauridæ and Lariosauridæ, met in median symphysis, but, owing to the antero-posterior expansion of their inner ends and the absence or reduction of the interclavicle, their symphysis is much longer. The close union of the clavicles with one another and with the interclavicle at their inner ends, and with the scapulæ at their outer ends, among the Nothosauridæ and Lariosauridæ seems to imply the mechanical necessity of great rigidity in the ventral portion of the pectoral arch of these swimming reptiles, and the changes undergone by the shoulder-girdle of *Cryptochlidus*, in its passage from its immature condition to the adult state, all tend to render this rigidity more perfect. For instance, in the stage shown in fig. 3 A the ventral plate of the scapula is growing inward towards the middle line behind the posterior edge of the clavicle, and near the outer border it is sending a plate

forward beneath the same bone, both tending to increase the firmness of their union by adding to the surface in which they are in contact. The continued extension inwards of the ventral bars of the scapulæ finally brings about their union in the middle line, and at the same time their extension forwards beneath the clavicles gradually shuts these bones off from the ventral surface, so that we are met by the anomalous condition of the membrane-bones lying on the inner side of bones developed from cartilage. That this condition is a purely secondary one is clear from the foregoing description, so that the argument that the elements in question cannot be true clavicles on account of their deep-seated position falls to the ground.

It is evident that when the ventral rami of the scapulæ have once met in the middle line, they usurp the function of the clavicular arch as anterior ventral support of the pectoral girdle to a gradually increasing extent; this may account for the reduction and great variability of the clavicles in some forms (e. g. *Murcenosaurus*, in which an interclavicle is present). For the same reason the eventual disappearance of the clavicular arch is very probable, and appears to have taken place in the Cretaceous genus *Elasmosaurus*.

The changes undergone by the coracoids during growth also tend to increase the rigidity of the girdle. Their median symphysis is gradually prolonged both backwards and forwards; in the latter direction it is carried far in advance of the glenoid cavity, and finally becomes continuous with the scapular symphysis, so that in the adult the scapulæ and coracoids form a continuous union in the mid-ventral line from one end of the pectoral girdle to the other.

How far the above explanation of the peculiarities of the Elasmosaurian pectoral girdle applies to other types of structure, such as those occurring in *Pliosaurus* and *Plesiosaurus*, cannot now be considered; but there appears to be no reason why they should not be regarded merely as less specialized conditions of the same kind of modification.

As to the homology of the ventral ramus of the scapula, there seems no reason whatever for considering it to represent a precoracoidal element fused to the scapula, all the facts leading to the conclusion that it is merely a secondary outgrowth from the latter. That this outgrowth is homologous with the ventral ray of the Chelonian scapula is highly probable; and if it be so regarded, it is interesting to note that while in the Plesiosaurs it lies ventral to the clavicular arch, in the Chelonia it is dorsal to it (*i. e.* to the entoplastron and

epiplastra). The name "proscapula," as suggested by Baur*, may be applied to this process both in the *Chelonia* and in the *Sauropterygia*; but since, as Professor Howes has pointed out to me, the use of the term as a substantive is open to the objection that it implies the existence of a distinct element, it will be better to speak of it as the "proscapular process."

XLIII.—*Report upon the Chilopoda and Diplopoda obtained by P. W. Bassett-Smith, Esq., Surgeon R.N., and J. J. Walker, Esq., R.N., during the Cruise in the Chinese Seas of H.M.S. 'Penguin,' Commander W. U. Moore commanding.*
By R. I. Pocock, of the British Museum of Natural History.

[Plate XI.]

THE following report is based primarily upon the species of *Chilopoda* and *Diplopoda* obtained by Messrs. J. J. Walker and P. W. Bassett-Smith during the cruise of H.M.S. 'Penguin' in the Chinese Seas. But, to render the account of further interest and value, notices have been incorporated of all the Japanese and Chinese species of these two groups that are contained in the British Museum, including descriptions of a large number of new forms obtained by Mr. Holst principally in the islands of Loo-Choo and in Formosa. It is hoped that by this means the paper may prove to be an index of the affinities of the *Chilopod* and *Diplopod* fauna of the Chinese area.

So far as can at present be judged from the material at my disposal, this fauna is a most curious mixture, being identical in most of its features with that of the central and southern part of the United States of America, with an infusion from the Indo-Malayan area of the Oriental Region and from the southern and central portions of the Palæarctic.

Taking first the *Chilopoda*, it seems evident that such forms as *Scutigera clunifera*, *Scolopendra morsitans* and *subspinipes* (with its varieties), and the species of *Otostigmus* are migrants from the Oriental Region; the *Lithobiidæ* are both Palæarctic and North American, while *Otocryptops sexspinosus* is essentially a North-American species. In the *Diplopoda* the species of *Polydesmus* and of *Iulus* show affinities with both

* Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 421.